ACRES AFFECTED AND LOSSES CAUSED BY PITCH CANKER DISEASE, 1980

Forest Insect and Disease Information System (FIDIS) Levels I and II

Steven W. Oak, Plant Pathologist[1/]
Noel D. Cost, Resource Analyst[2/]
Joseph F. Glover, Associate Mensurationist[2/]

ABSTRACT

Damage to southern pines by pitch canker disease includes tree mortality, growth suppression, stem deformation, seed and cone losses, and loss of seedlings in infected nursery seedbeds and subsequent outplantings. Slash pine is the only species damaged at economic levels in forest stands. By extrapolation of Forest Inventory and Analysis data collected in Florida to other states, it is estimated that 551,500 acres of slash pine are infected with pitch canker at an average incidence of 13.6 percent per affected acre. Slash pine volume lost to the disease is estimated at 13.82 to 30.67 million cubic feet annually, with 70 to 80 percent caused by growth suppression. An estimated 2.46 to 3.44 million slash pines were rendered unusable for solid wood products because of stem deformation. Most of the damage occurs on privately owned lands in Florida and southeastern Georgia. Estimates of seed and cone losses are unavailable; but, given the high value of improved seed, they could be significant. Nursery and outplanting losses are low and not quantified.

This report satisfies the requirements of the Forest Insect and Disease Information System (FIDIS) Levels I and II and represents the first attempt to quantify damage caused by pitch canker southwide.

INTRODUCTION

In order to provide current information on losses to forest pests in the United States, the USDA Forest Service instituted the FIDIS. Two levels are recognized. Level I requires the reporting of acreage affected by a given pest according to ownership and state in the region of its occurrence. Level II requires the reporting of the number and volume of trees killed and the growth lost.

This paper reports FIDIS Levels I and II for pitch canker disease. An estimate of the number of trees deformed and unusable for solid wood products is also made.

1/ USDA Forest Service, Forest Pest Management, Southeastern Area, State and Private Forestry, Asheville, N.C.

2/ USDA Forest Service, Forest Inventory and Analysis Work Group, Southeastern Forest Experiment Station, Asheville, N.C.

Hosts

Pitch canker disease is caused by Fusarium moniliforme var. subglutinans and can be found damaging pines from Virginia to eastern Texas. Many species are affected, including all of the commercially important southern pine species (4, 5, 7, 11, 13). Observations of damage in forest stands and the results of artificial inoculation trials indicate that slash (P. elliotii var. elliotii and var. densa), loblolly, shortleaf, and Virginia pines are most susceptible (1, 7, 11, 13, 17). The disease can affect trees of all ages and those growing in natural stands, plantations, seed orchards, and ornamental settings. The most severe damage has occurred in plantations of slash pine 8 to 25 years old and in slash, loblolly, and shortleaf pine seed orchards across the South (1, 9, 12, 13, 17-19, 21, 22). Recent investigations have shown that the fungus can damage cones in seed orchards and infect seed and nursery-grown slash and loblolly pine seedlings. Fungus-infected seed may be killed or remain viable and later succumb to pre- or post-emergence damping-off (2, 20). Losses have been observed in outplantings of seedlings from infected nursery seedbeds.

Damage

The most common symptom associated with infection is branch dieback, with associated copious resin flow. The fungus kills by girdling and inducing xylem resin soaking, thereby interrupting water transport. Though main stem cankers can occur, repeated infection of the terminal and upper laterals of young trees is more common and can result in stem deformity. This can render the tree unusable for most sawn wood products. Tree mortality can result from heavy crown infection, but growth loss is considered the most serious impact of the disease (9, 19, 21, 22).

Biology

The fungus produces spores on infected branches which are disseminated most efficiently in the air during rainy, windy periods in summer (6). The fungus requires a wound to infect the host and can be vectored by the deodar weevil (Pissodes nemorensis) (8). This insect feeds on the phloem of the current year's growth through small feeding punctures and breeds in stressed, dying trees, which can be common in heavily pitch-cankered stands.

The disease has been intermittently epidemic in localities since the mid-1950's, with the most recent and severe episode occurring between 1975-79, when several thousand acres of slash pine plantations were salvage harvested before economic maturity, principally in the east-central peninsula of Florida. Infection levels exceeded 90 percent in some plantations, with 25 percent mortality documented (9).

The disease is currently not as damaging as the 1975-79 epidemic, but is widely distributed in Florida and across the South. Some observers indicate that younger slash pine plantings (around age 5) are becoming infected. Reports of recent surveys of the Apalachicola National Forest in Florida state that the widening distribution of the disease in the Forest increases the potential for economic loss should conditions become favorable for another epidemic (13).

Controls for the disease are not yet available. Disease resistance breeding shows some promise as part of an integrated system to minimize damage. Other tools which may contribute to disease management include salvage harvest of heavily diseased stands, burning of logging debris from harvested, infected trees, practices to improve stand vigor (thinning, water management), and using natural regeneration techniques or native seed sources in artificial regeneration (7).

Survey

In 1976, a statewide survey of slash pine plantations and seed orchards in Florida was conducted (21). This coincided with the height of the most recent epidemic. The disease was found in all sampled counties (59 of 67 total counties) and in all age classes. Trees age 17 years and older were most severely affected. It was estimated that 1.1 million acres were infected, and the disease was most abundant in eastern and central Florida. This survey and other observations showed the disease to be highly clonal in slash pine seed orchards.

Survey efforts are ongoing on the Apalachicola National Forest. The entire Forest has been surveyed in alternate years since 1976 to provide disease progress monitoring and to reveal possible associations with management practices.

SURVEY METHODS
Forest Inventory and Analysis (FIA)

Detailed information on FIA methods is available elsewhere (3, 16). Only certain points important to damage assessment will be discussed. Procedures initiated to classify and report tree damage classes (including disease) have only recently been instituted. Not all southeastern states have been evaluated, but data collected in 1978-80 is available for Florida. Pitch canker, important in Florida slash pine plantations, is one of 26 damage types evaluated. If more than one damage type occurs on a given plot tree, the most severe is recorded. Therefore, where multiple conditions occur, pitch canker infection may go unreported and be underestimated.

Since data on pitch canker are unavailable for other states, Florida data provide the basis for southwide projections of disease. Previous observations (21) indicate that the disease does not equally affect all parts of Florida. In order to provide some geographic sensitivity, regions within Florida will be used in characterizing current disease and projecting Florida conditions to the South. Regions are established after Boyce, et al. (1975) (Fig. 1). Reporting will be confined to slash pine because the literature indicates economic losses have occurred only in that species.

Forest Inventory and Analysis data for Florida were provided in two lists.

FIGURE 1. TIMBER PRODUCTION PROVINCES FOR THE SLASH PINE ECOSYSTEM. (FROM: BOYCE, S.G., ET. AL. 1975).

List 1 for each slash pine plot:

Ownership class
Stand age
Stand origin
Total cubic foot volume of all live trees 5.0 inches d.b.h. and larger (per acre)
Infected cubic foot volume of all live trees 5.0 inches d.b.h. and larger (per acre)
Total number of all live trees 1.0 inch d.b.h. and larger (plot)
Total number of all live trees 1.0 inch d.b.h. and larger (per acre)
Total number of all live infected trees 1.0 inch d.b.h. and larger (plot)
Total number of all live infected trees 1.0 inch d.b.h. and larger (per acre)
Percent of all live trees 1.0 inch d.b.h. and larger infected (plot)
Area expansion factor
Volume expansion factor

Ownership Classes

1. National Forest
2. Other Federal
3. Other Public
4. Private

List 2 for each infected plot:[1/]

		Coordinates		
Unit	County	East-West	North-South	Infection > 10%
X	XX	XXX	XXX	Yes (1) No (2)

Data were provided in this format to retain owner confidentiality. Pinpointing plots by merging list 1 with list 2 was not possible.

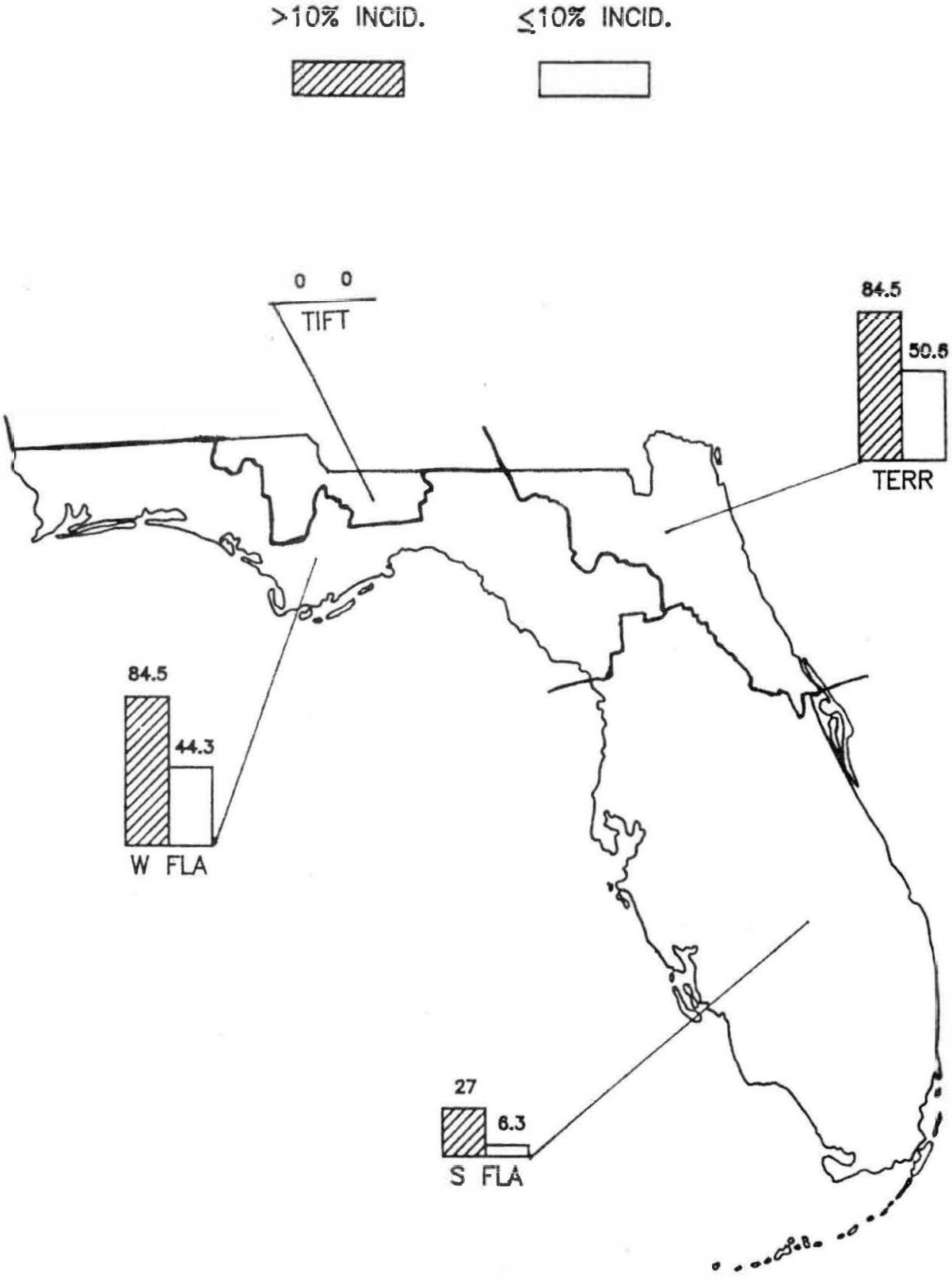
SURVEY RESULTS

There are 4,680 permanent FIA field plots in Florida, and 1,558 of those were classified as slash pine forest type in 1980. These represent 5,297,588 acres. Ninety plots had pitch canker, with 64 percent having more than 10 percent of the trees infected. Average incidence of infected plots was 13.6 percent.

Infected plot mapping showed the disease was not evenly distributed or equally severe across the state, confirming earlier reports (21) and observations. The number of acres affected by pitch canker is shown by Florida region in Figure 2.

1/ Any slash pine plot having a live tree 1.0 inch d.b.h. or larger with pitch canker was classed as infected.

FIGURE 2. ACRES OF PITCH CANKER INFECTED SLASH PINE IN FLORIDA BY REGION (X000).



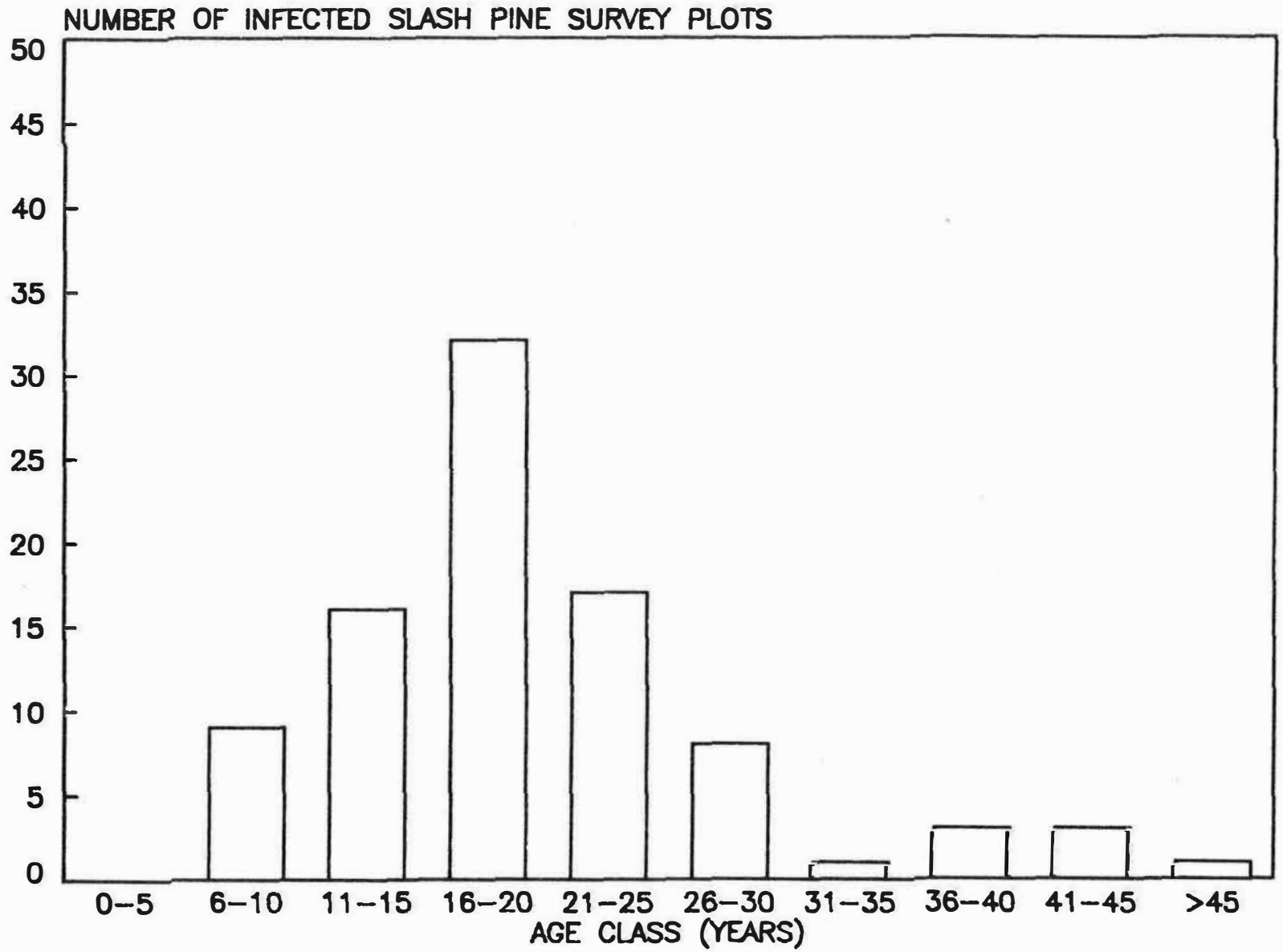
Infected slash pine stands are more common in the east and north-central peninsula than in other parts of the state. While there are nearly twice the number of slash pine acres in the west Florida region as the terrace region, the number of infected plots is nearly the same, indicating a lower incidence of pitch canker infected slash pine stands in west Florida. The incidence of infected stands is lower still in the south Florida region but, when present, affects a higher percentage of trees in the stand. No pitch canker was found in the Tifton region.

The 16-20 year old age class was most commonly affected (Fig. 3). Over 80 percent of the infected plots were between 8 and 25 years old. This represents differences in susceptibility to the disease due to age and stand origin (planted or natural), because only one-half and one-third of the planted and total slash pine acres, respectively, are between age 8 and 25 (Raymond M. Sheffield, FIA Work Group, unpublished data).

LOSS ASSESSMENT
Methods and Results

The tables which follow are derived from the best estimates of tree mortality, growth loss, and stem deformation available in the published literature. Differing research methods and reporting formats necessitate some data transformations to a common form for the purpose of this paper. Since reporting a precise estimate is impossible for a geographic area as large and diverse as the slash pine range, high and low values are used in all computations, except those done to derive ACRES INFECTED-COMMERCIAL FOREST LAND. Forest Inventory and Analysis survey data provide that estimate. Justification for the values used in computations is found in the appendix.

FIGURE 3. AGE DISTRIBUTION OF PITCH CANKER INFECTED FIA PLOTS IN FLORIDA.



1. ACRES INFECTED-COMMERCIAL FOREST LAND

Rationale

See Table I for listing of slash pine acres in the South, partitioned by Timber Production Provinces (regions).

NOTE: Regional acres from Boyce, et al. (Table I) were collected during the FIA survey completed in 1970 and differ from data collected in the 1980 survey (2.3 percent fewer acres in Florida in 1980). Since data for correction of acreages in regions of other states is not currently available, 1970 figures will be used for all regional acreages. Infected acres are projected from current data, which is based on fewer total acres. This results in a slight underestimate (.1 - .2%) of the percent of all acres which are infected in each Florida region.

1. Determine average area expansion factor for infected plots in Florida (FIA list 1).

2. Determine number of infected plots (FIA list 2) in each region in Florida (Boyce, et al.).

3. Multiply 1. above by 2. above for each region in Florida. Compute percent of total acres infected in each Florida region (Table II).

4. Separation of infected acres by ownership in Florida accomplished by summing acreage expansion factors for infected plots in each ownership class (FIA list 1). Shown in Florida line of Table III.

5. By consulting a slash pine range map (found on page 2 of Boyce, et al., 1975) and ownership maps of states other than Florida, an estimate of slash pine acreage in a given ownership/region/state combination was made. NOTE: Slash pine acres are concentrated in private holdings (farm, forest industry) in states outside Florida. Public lands outside Florida (National Forests, other federal, other public) contain only small amounts of the total slash pine resource. When percent acres infected (Table II) are applied to these small acreages, the net acres infected by region is projected as small.

6. Percent of total acres infected in each Florida region (Table II) multiplied by 5. above.

7. Infected acres in a region summed according to ownership and state (Table III [FIDIS Level I]).

Table I.--Total commercial forest slash pine acres southwide, by region, 1970 (Boyce, et al.).

Region	Location						
	Fla.	Ga.	Ala.	Miss.	S. Car.	Louis.	Total
I. Terrace	1,701,000	2,518,000	-[1/]	-	-	-	4,219,000
II. Tifton	325,000	1,582,000	181,000	-	-	-	2,088,000
III. W. Florida	2,430,000	-	364,000	565,000	-	118,000	3,477,000
IV. S. Florida	969,000	-	-	-	-	-	969,000
V. Plantation	-	423,000	-	-	574,000	-	997,000
Total	5,425,000	4,523,000	545,000	565,000	574,000	118,000	11,750,000

1/ No slash pine acreage in region/state combination.

Table II.--Commercial forest acres infected with pitch canker disease in Florida, by region, 1980. (Infected Acres from FIA, 1980; Total Acres from Boyce, et al., 1975.)

Region	Total Acres (1970)	Infected Acres (1980)	% Acres Infected
I. Terrace	1,701,000	135,000	7.9
II. Tifton	325,000	0	0
III. W. Florida	2,430,000	129,000	5.3
IV. S. Florida	969,000	33,000	3.4
V. Plantation	-	-	-
Total	5,425,000	297,000	5.5

- Acreage in region = zero.

Table III.--Commercial forest acres of slash pine infected with pitch canker disease, by state and ownership, 1980.

Location	Ownership				
	Nat. For.	Other Fed.	Other Pub.	Private	Total
Florida	2,800	0	8,300	286,000	297,100
Georgia	-	*	*	198,900	198,900
Alabama	*	*	*	19,300	19,300
Mississippi	*	*	*	29,900	29,900
Louisiana	-	-	*	6,300	6,300
South Carolina	*	*	*	*	*
Total	2,800	*	8,300	540,400	551,500

- Acreage in ownership type/state zero or insignificant in slash pine range.

* Acreage in ownership type/state is a very small percentage of total slash pine acreage and disease present at undetectable levels.

2. MORTALITY

A. Number of Trees

Rationale

1. *Number of infected trees (1" d.b.h. minimum) per acre in Florida averaged* for each ownership class (FIA list 1).

National Forests	= 64 infected trees/acre
Other Federal	= 0 infected trees/acre
Other Public	= 57 infected trees/acre
Private	= 90 infected trees/acre

2. Assume same infection incidence on the same ownerships in different states.

3. Number of infected acres by state and ownership (from Table III).

4. Multiply 1. above by 3. above to yield total number of infected trees 1 inch d.b.h. and larger by state/ownership (summarized in Table IV).

5. Multiply values in Table IV by .04 and .06, except in southern Florida region (Table II) where .01 and .02 are used. NOTE: Most infected acres in southern Florida are Privately owned. The remainder are Other Public.

6. Sum by owner and state (Table V).

B. Volume of Trees On Commercial Forest Land

Rationale

1. *Volume of infected trees (5" d.b.h. minimum) per acre by ownership in* Florida (FIA list 1).

2. Number of infected trees (1" d.b.h. minimum) per acre by ownership in Florida (FIA list 1).

3. Divide 1. above by 2. above to determine volume per infected tree. NOTE: Volume and number of trees based on different criteria (5" and 1" d.b.h., respectively) will result in underestimate of volume of infected trees and volume lost to mortality.

4. Multiply 3. above by values in Table V (Table VI).

Table IV.--Number of trees on commercial forest land 1 inch d.b.h. and larger infected with pitch canker, by state and ownership.

Location	Ownership				
	Nat. For.	Other Fed.	Other Pub.	Private	Total
Florida	179,200	0	474,100	25,737,800	26,391,100
Georgia	-	*	*	17,903,000	17,903,000
Alabama	*	*	*	1,736,300	1,736,300
Mississippi	*	*	*	2,695,000	2,695,000
Louisiana	-	-	*	562,900	562,900
South Carolina	*	*	*	*	*
Total	179,200	*	474,100	48,635,000	49,288,300

- Acreage in ownership type/state zero or insignificant in slash pine range.

* Acreage in ownership type/state is small percentage of total slash pine acreage and disease present at undetectable levels.

ble V.--Number of trees on commercial forest land 1 inch d.b.h. and larger killed by pitch canker southwide, 1980.

State/% Mortality	Ownership				Total
	Nat. For.	Other Fed.	Other Pub.	Private	
Florida					
4% 1/	7,200	0	19,000	1,029,500	1,055,700
6% 1/	10,800	0	28,400	1,544,300	1,583,500
Georgia					
4%	-	*	*	716,100	716,100
6%	-	*	*	1,074,200	1,074,200
Alabama					
4%	*	*	*	69,500	69,500
6%	*	*	*	104,200	104,200
Mississippi					
4%	*	*	*	107,800	107,800
6%	*	*	*	161,700	161,700
Louisiana					
4%	-	-	*	22,500	22,500
6%	-	-	*	33,800	33,800
South Carolina					
4%	*	*	*	*	*
6%	*	*	*	*	*
Total					
4%	7,200	*	19,000	1,945,400	1,971,600
6%	10,800	*	28,400	2,918,200	2,957,400

1/ Mortality in southern Florida region calculated at 2% of infected trees (Bethune and Hepting). Mortality in other Florida regions calculated at 4 or 6%.

- Acreage in region = zero.

Acreage in ownership type/state is small percentage of total slash pine acreage and disease present at non-damaging levels.

ble VI.--Volume of trees on commercial forest land 5 inches d.b.h. and larger killed by pitch canker southwide, 1980.

State/% Mortality	Ownership				
	Nat. For.	Other Fed.	Other Pub.	Private	Total
	- - - - - - - - - - - - - - - -		cubic feet	- - - - - - - - - - - - - - - -	
Florida					
4%	0 1/	0	33,000	2,038,800	2,071,800
6%	0 1/	0	49,500	3,073,100	3,122,600
Georgia					
4%	-	*	*	1,425,100	1,425,100
6%	-	*	*	2,137,600	2,137,600
Alabama					
4%	*	*	*	138,200	138,200
6%	*	*	*	207,300	207,300
Mississippi					
4%	*	*	*	214,500	214,500
6%	*	*	*	321,800	321,800
Louisiana					
4%	*	*	*	44,800	44,800
6%	*	*	*	67,200	67,200
South Carolina					
4%	*	*	*	*	*
6%	*	*	*	*	*
Total					
4%	*	*	33,000	3,861,400	3,894,400
6%	*	*	49,500	5,807,000	5,856,500

1/ Volume of killed trees on National Forest = zero (less than 5" dbh).

- Acreage in state/ownership class = zero.

* Acreage in state/ownership is small percentage of total slash pine acreage and disease present at non-damaging levels.

3. GROWTH LOSS
Volume Exclusive of Mortality

Rationale

1. Acres infected by ownership and state (Table III).

2. Multiply 1. above by 18 and 45 ft^3/ac/yr to yield range of loss values (Table VII).

ole VII.--Volume lost to pitch canker by growth suppression southwide on commercial forest land, 1980.

State/Volume Loss	Ownership				
	Nat. For.	Other Fed.	Other Pub.	Private	Total
	- - - - - - - - - - - - - - - -		cubic feet		- - - - - - - - - - - - - -
Florida					
18 ft^3/ac	50,400	0	149,700	5,147,600	5,347,700
45 ft^3/ac	126,000	0	374,300	12,868,900	13,369,200
Georgia					
18 ft^3/ac	-	*	*	3,580,600	3,580,600
45 ft^3/ac	-	*	*	8,951,500	8,951,500
Alabama					
18 ft^3/ac	*	*	*	347,300	347,300
45 ft^3/ac	*	*	*	868,100	868,100
Mississippi					
18 ft^3/ac	*	*	*	539,000	539,000
45 ft^3/ac	*	*	*	1,347,500	1,347,500
Louisiana					
18 ft^3/ac	-	-	*	112,600	112,600
45 ft^3/ac	-	-	*	281,400	281,400
South Carolina					
18 ft^3/ac	*	*	*	*	*
45 ft^3/ac	*	*	*	*	*
Total					
18 ft^3/ac	50,400	*	149,700	9,727,100	9,927,200
45 ft^3/ac	126,000	*	374,300	24,317,400	24,817,700

Acreage in state/ownership class = zero.

* Acreage in state/ownership class is small percentage of total slash pine acreage and disease present at non-damaging levels.

4. PRODUCT DEVALUATION
Stem Deformation of Trees on Commercial Forest Land

Rationale

1. Number of trees infected by ownership and state (Table IV).

2. Multiply 1. above by .05 and .07 to yield range of deformation loss values (Table VIII).

Table VIII.--Number of trees on commercial forest land 1 inch d.b.h. and larger made unusable for solid wood products because of pitch canker-caused deformation, by state and ownership, 1980.

	Ownership				
State/% Deformed	Nat. For.	Other Fed.	Other Pub.	Private	Total
Florida					
5%	9,000	0	23,700	1,286,900	1,319,600
7%	12,500	0	33,200	1,801,600	1,847,300
Georgia					
5%	-	*	*	895,100	895,100
7%	*	*	*	1,253,200	1,253,200
Alabama					
5%	*	*	*	86,800	86,800
7%	*	*	*	121,500	121,500
Mississippi					
5%	*	*	*	134,800	134,800
7%	*	*	*	188,700	188,700
Louisiana					
5%	-	-	*	26,300	26,300
7%	-	-	*	36,900	36,900
South Carolina					
5%	*	*	*	*	*
7%	*	*	*	*	*
Total					
5%	9,000	*	23,700	2,429,900	2,462,600
7%	12,500	*	33,200	3,401,900	3,447,600

- Acreage in state/ownership class = zero.

* Acreage in state/ownership class is small percentage of total slash pine acreage and disease present at non-damaging levels.

Seed and Cone Loss

Pitch canker has been shown by several observers to be highly clonal in loblolly and slash pine seed orchards (12, 17, 21, author observations) and to seriously affect cone yields in loblolly orchards. An 86 percent decline in cone yield was ascribed to pitch canker at one loblolly orchard in Mississippi (12). High disease incidence and severity have also been reported in a loblolly pine orchard in North Carolina and in slash, Virginia, and shortleaf pine orchards in Louisiana and Alabama (12, 17).

Screening of selected slash pine seedlots has shown internal pitch canker contamination ranging from 0 to 11 percent (G. M. Blakeslee, personal communication). Loblolly pine seed is similarly affected (R. L. Anderson, personal communication). Since the implications of fungus contamination on and in apparently sound seed is incompletely understood, the translation of comtaminated seed to seed loss cannot be made at this time. However, at the high values of seed orchard cones and seeds (conservatively reported as $100 to $500 per pound of seed), even a low incidence of pitch canker could amount to large dollar losses.

Seedling Loss

The low incidence of the disease in slash and loblolly pine seedbeds across the South results in very little impact. Outplanting losses occur, but have not yet been quantified and reported.

CONCLUSIONS

This report is based on the most current survey data available for pitch canker disease of slash pine in Florida. Tables II through VIII report estimates of annual losses. Pitch canker disease does not affect the population of slash pines equally in every year. Most studies cited here were conducted during or shortly after epidemic periods. Losses would vary according to the activity of the disease in different years.

Extrapolation to other states, as done here, assumes that disease incidence and severity are uniform between region/state combinations and that growth loss and the rate of tree mortality and stem deformation in the population of diseased trees are the same between regions and states. The regions adopted from Boyce, et al. were originally constructed on the basis of differences in growth rate and physiographic characters. This is one possible source of error in the estimates reported. The magnitude of this potential source of error is not known. However, extrapolation of infection levels to states outside of Florida does not result in misstatements, as verified by the observations of the author and others; e.g., that pitch canker is by far most damaging on privately managed lands (predominantly plantations) and is most prevalent in Florida and southern Georgia.

Other sources of error are inherent in the methodology and were pointed out in the appropriate Rationale section. They are: 1) basing regional acreages on earlier surveys (i.e., 1970 for Florida), but infected acres on the current (1978-80) survey; 2) small acreages in ownership classes outside of Florida are not accounted for in computations; and 3) volume and number of

infected trees are based on different criteria (5" and 1" d.b.h., respectively). The first two sources of error are not expected to account for more than 2 to 3 percent in any cell of the tables generated. The amount of error inherent in the third source is not known, but does result in an underestimate. However, it may be compensated for in this report because the literature does not account for ingrowth (increased growth by unaffected trees adjacent to diseased trees) in reporting growth loss per acre. In summary, the errors inherent on the methodology for determining acres affected, number and volume of trees killed, and growth loss are considered to be small and do not seriously flaw this analysis.

The deformation values are probably overestimated. Sources providing estimates of deformation rates among diseased trees indicate that deformed trees may recover to produce logs suitable for sawtimber. More investigations are needed to provide data which reports only trees expected to be deformed at harvest.

LITERATURE CITED

1. Arvanitis, L. G. and I. L. Duncan. 1982. A preliminary assessment of the effect of pitch canker on tree growth and volume in certain slash pine plantations. Sch. of For. Resour. and Cons., I.F.A.S., Univ. of Florida, Gainesville, Florida. 64 p.

2. Barnard, E. L. and G. M. Blakeslee. 1980. Pitch canker disease of slash pine seedlings: A new disease in forest tree nurseries. Plant Disease 64:695-696.

3. Bechtold, W. and H. A. Knight. 1982. Florida's forests. Resour. Bull. SE-62. USDA For. Serv., Southeast. For. Exp. Stn., Asheville, N.C.

4. Berry, C. R. and G. H. Hepting. 1959. Pitch canker of southern pines. USDA For. Serv., For. Pest Leafl. 35. 3 p.

5. Bethune, J. E. and G. H. Hepting. 1963. Pitch canker damage to south Florida slash pine. J. For. 61:517-522.

6. Blakeslee, G. M., R. D. Dorset, and S. W. Oak. 1979. Inoculum dispersal of the pine pitch canker fungus, Fusarium moniliforme var. subglutinans. Phytopathology 69:1022 (Abstr.)

7. Blakeslee, G. M., L. D. Dwinell, and R. L. Anderson. 1980. Pitch canker of southern pines. Identification and management considerations. USDA For. Serv., State and Private For., Southeast Area, For. Rep. SA-FR 11. 11 p.

8. Blakeslee, G. M., S. W. Oak, and J. L. Foltz. 1981. Pissodes nemorensis: A vector and wounding agent for pitch canker disease of slash pine. In: Proceedings of the Southwide Forest Disease Workshop, Gainesville, Florida, January 13-15, 1981.

9. Blakeslee, G. M. and S. W. Oak. 1979. Significant mortality associated with pitch canker infection of slash pine in Florida. Plant Dis. Reptr. 63:1023-1025.

10. Boyce, S. G., J. P. McClure, and H. S. Sternitzke. 1975. Biological potential for the slash pine ecosystem. USDA For. Serv., Res. Pap. SE-141. 29 p.

11. Dwinell, L. D. 1978. Susceptibility of southern pines to infection by Fusarium moniliforme var. subglutinans. Plant Dis. Reptr. 62:108-111.

12. Dwinell, L. D., P. L. Ryan, and E. G. Kuhlman. 1977. Pitch canker of loblolly pine in seed orchards. In: Proceedings of the Fourteenth Southern Forest Tree Improvement Conference, Gainesville, Florida, June 1977. p. 130-137.

13. Fisher, V. J. and R. L. Anderson. 1980. Distribution, incidence, and damage caused by the pitch canker fungus on slash pine, Apalachicola National Forest, Florida, 1980. USDA For. Serv., State and Private For., Southeast. Area Rep. No. 80-1-20.

14. Hepting, G. H. and E. R. Roth. 1946. Pitch canker, a new disease of some southern pines. J. For. 44:7442-7444.

15. Hepting, G. H. and E. R. Roth. 1953. Host relations and spread of the pine pitch canker disease. Phytopathology 43:475. (Abstr.)

16. Jacobi, W. R., R. L. Anderson, and N. D. Cost. 1981. Multiresource inventories: procedures for assessing the damage caused by insects and diseases. USDA For. Serv., Res. Pap. SE-221, 11 p., Southeast. For. Exp. Stn., Asheville, N.C.

17. Kelly, W. D. and J. C. Williams. 1981. Differences among loblolly pine clones in susceptibility to pitch canker. In: Proceedings of the Southwide Forest Disease Workshop, Gainesville, Florida, January 13-15, 1981.

18. Krause, S. H. and W. Witcher. 1977. Survey of pine pitch canker in South Carolina. Plant Dis. Reptr. 61:976-978.

19. Laird, P. P. and C. W. Chellman. 1972. An evaluation of a pitch canker outbreak in a Florida slash pine plantation. USDA For. Serv., State and Private For., Southeast. Area Rep. 73-1-16. 7 p.

20. Miller, T. and D. L. Bramlett. 1978. Fungi associated with damage to strobili, cones, and seed of slash and loblolly pines. Phytopathology News 12:207 (Abstr.)

21. Phelps, W. R. and C. W. Chellman. 1976. Evaluation of pitch canker in Florida slash pine plantations and seed orchards, 1976. USDA For. Serv., State and Private For., Southeast. Area. 22 p.

22. Schmidt, R. A. and E. M. Underhill. 1974. Incidence and impact of pitch canker in slash pine plantations in Florida. Plant Dis. Reptr. 58:451-459.

APPENDIX

1. Justification for values used in computing the number and volume of dead trees:

Author	Date	Annual Mortality Pitch Cankered Trees	Species/Stands
Laird & Chellman	1969-71	8.5 - 11.8%	1 *P. elliottii* plantation 11 yrs. old
Schmidt & Underhill	1969-71	4.1 - 6.3%	16 *P. elliottii* plantations 11 and 19 yrs. old
Bethune & Hepting	1955-60	1 - 2% 1/	16 *P. elliottii* var. *densa* plots in natural stands 14 - 21 yrs. old

1/ Based on 8.7 percent mortality of pitch cankered trees over a 5-year period.

Annual mortality of pitch cankered trees is assumed to be 4 and 6 percent, based on the greatest number of observations made over the largest area (Schmidt & Underhill), except for the southern Florida region, where *P. elliottii* var. *densa* predominates. One and 2 percent will be used in southern Florida region (Bethune & Hepting).

Most observers agree that annual mortality in pitch cankered stands attributable to disease ranges from less than 1 to 2 percent of all trees (1, 4, 17, 19, 20).

2. Justification for values used in computing growth loss, exclusive of mortality:

Author	Date	Volume Lost to Disease - Exclusive of Mortality	Comments
Schmidt & Underhill	1969-71	.23 cords/ac/yr	
Phelps & Chellman	1976	.56 cords/ac	Authors assumed 25% incidence and computed a loss of 1.4 cords/ac. If we assume 10% incidence (which approximates Schmidt & Underhill levels), computed loss is .56 cords/ac. This represents one estimate of annual loss.

Author	Date	Volume Lost to Disease - Exclusive of Mortality	Comments
Arvanitis & Duncan	1976-81	.58 cords/ac/yr	Twenty-seven plots in loblolly and slash pine stands in Georgia and Florida. Total wood volume lost was 434.67 ft^3/ac, which converts to approximately .97 cords/ac/yr. Schmidt & Underhill report 40% of total volume loss due to mortality. If applied to .97 cords/ac/yr, computed loss to growth suppression alone is .58 cords/ac/yr.

Annual loss to pitch canker by growth suppression is assumed to be .2 and .5 cords/ac/yr (converts to 18 and 45 ft^3/ac/yr, respectively, assuming 90 ft^3/cord). The values reported above represent repeated observations over a wide geographic area and/or time frame.

3. Justification for values used in computing annual stem deformity:

Author	Date	Annual Stem Deformation Pitch Cankered Trees	Comments
Laird & Chellman	1969-71	7.5%	Authors tabulated severely damaged trees (> 1/3 of top killed). We assume these have main stem deformation. Three observations separated by 19 months in the same stand provided estimates of loss (15-19%) (15% ÷ 2 yrs. = 7.5% annual stem deformity). Deformation status may improve as trees recover from disease. Authors state plantation management limited to pulpwood opportunities by disease.
Arvanitis & Duncan	1976-81	6.8%	Accumulated stem deformity over the 5-year period was 34% (34% ÷ 5 yrs. = 6.8% annual stem deformity). Author states deformation status changes as trees recover.

The authors of the cited reports state that deformation status may change as trees recover from the disease. Because of this, we consider 7 percent to be an artificially high rate of permanent deformation in pitch-cankered trees. A 5 percent deformation rate, supported by recent evaluations by the first author on the Apalachicola National Forest, Florida, is used to compute the low rate for stem deformation among diseased trees. However, this may also be higher than the true rate of deformation, since the evaluated trees were young and have ample time to recover stem form acceptable for sawtimber. Further, intermediate cuttings where deformed trees are removed could result in little or no loss, if the cuttings were conducted after trees reach pulpwood size.

FPM L.b
Gen

Forest Pest Management
Asheville Field Office

Report #82-1-38
September 1982

ACRES AFFECTED AND LOSSES CAUSED BY PITCH CANKER DISEASE, 1980

Forest Insect and Disease Information System (FIDIS)
Levels I and II

Prepared by: _____
Plant Pathologist

for _____
Resource Analyst

_____
Associate Mensurationist

Approved by: _____
for Harvey V. Toko
Staff Director
Forest Pest Management